

IN BRIEF

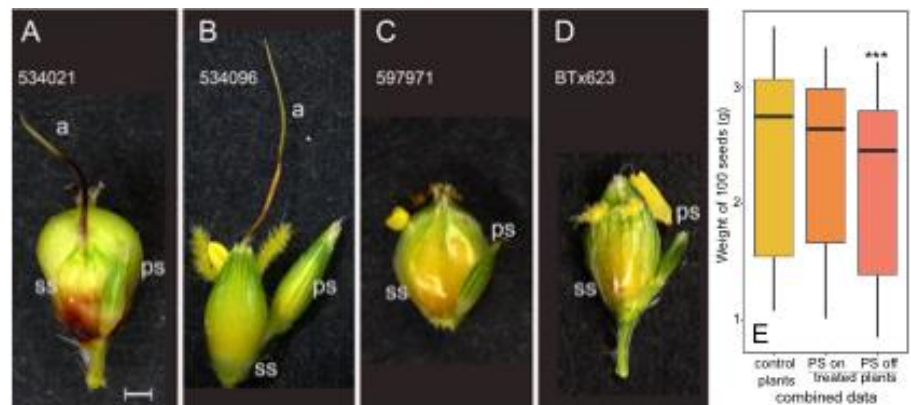
Gains in Grain Yield: A Pair of Spikelets Makes All the Difference, Even When One is Sterile

Mother Nature has a way of keeping seemingly useless structures around millions of years. Such structures are likely to have a use that is not obvious, although they could also be remnants of the evolutionary past without extant function, or non-functional but harmless byproducts of a different adaptive feature. In a fascinating study, first authors **Taylor AuBuchon-Elder and Viktoriya Coneva and coworkers (AuBuchon-Elder, Coneva et al., 2020)** report on the sterile spikelet of sorghum and related grasses, and provide support for the idea that this curious structure has been maintained for over 15 million years because it serves an important function.

Sorghum belongs to the grass tribe Andropogoneae, where paired spikelets house florets (Kellogg, 2015). In sorghum, a sterile (non-seed bearing) short-stalked pedicellate spikelet (PS) pairs with a fertile, stalkless sessile spikelet (SS) that ultimately bears grain. Additionally, the SS is awned. In wheat, awns can assimilate and transfer carbon to grain (Grundbacher, 1963). PS or awn function in sorghum has not been reported. With these observations and unknowns, the authors set out to understand the significance of the PS and awns in sorghum and related grasses.

Could the PS, awn, or both be a source of photosynthate for the SS? To find out, the authors initially conducted a series of ^{14}C labeling and pulse-chase experiments. For ^{14}C labeling, PS had significantly more $^{14}\text{CO}_2$ uptake compared to SS or awns. Additionally, a 24-hour pulse-chase experiment in intact panicles showed a decrease in percent ^{14}C in PS and concomitant percent increase in SS. This observation indicated the ^{14}C had translocated from PS to SS. The idea that PS could be a carbon source made sense because the authors observed stomata on the surface of PS, but not on SS or awns. Stomata are epidermal pores where CO_2 enters the organ for photosynthesis. The authors found ^{14}C labeling and pulse-chase results, along with appearance of stomata, to be consistent in two species distantly related to sorghum, *Themeda triandra* and *Andropogon schirensis*, which nicely broadened the context of their findings.

If the PS is a carbon source, metabolites produced by photosynthesis should be detectable. The authors explored this hypothesis in intact panicles of sorghum and *T.*

**Detachment of the sterile pedicellate spikelet reduces yield and fitness.**

Removal of the sterile, pedicellate spikelet (PS) reduces grain weight in the fertile, sessile spikelet (SS), represented in box and whisker plots as combined average weight of four Sorghum genotypes (Adapted from AuBuchon-Elder, Coneva et al., [2020], Figure 7.)

triandra with time-course exposure to $^{13}\text{CO}_2$ followed by LC-MS/MS. The authors cast a wide net in seining for metabolites from C_4 , C_3 , sucrose, or starch pathways. Consistent with previous ^{14}C labeling, PS had more ^{13}C than SS or awns. Time-course labeling showed the percent of unlabeled isotopologue fractions for individual metabolites of photosynthesis decreased at the early stages of $^{13}\text{CO}_2$ feeding, indicating carbon assimilation. Similarly, metabolites showed ^{13}C enrichment within five minutes of labeling. The authors conducted transcriptomic analysis of leaf, PS, SS, and awns from the two species, and filtered the data for differentially expressed genes encoding central carbon metabolic enzymes. In support, they found PS accumulated transcripts related to photosynthesis; likewise, these genes were downregulated in awns and SS.

PS have features of a carbon source; SS and awns have sink-like characteristics. How might this relationship impact yield? To address this question, the authors utilized four genotypes with diverse spikelet morphology and simply either detached the PS or left it intact on panicles at anthesis. When the panicles reached maturity, seed weights were collected. Importantly, the authors found a significant ~8.8% reduction in yield between controls (intact) and treatment (detached) across all genotypes (see Figure). Across individual genotypes, mean seed weights dropped from 8-13%, also suggesting that genetic variation in this trait might be leveraged to improve yield.

Photosynthetic PS in the Andropogoneae, albeit reduced in size, have not gone unnoticed by Mother Nature. Rather, they are significant structures that increase yield in domesticated sorghum and fitness in its wild relatives. **AuBuchon-Elder, Coneva and coworkers (AuBuchon-Elder et al., 2020)** have provided a solid foundation for future opportunities to improve sorghum. With a reference genome sequence (Paterson et al., 2009) and being amenable to genome engineering through transformation (Sander, 2019), prospects for gains in sorghum yield are far from sterile.

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