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Does Delayed Senescence Help in Increasing the Yield of Grain Crops?

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Commentary

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ABOUT THE STUDY

When there are no terminal stressors, grain crops are often only slightly constrained by the source during grain filling. It would only be reasonable to assume that delayed canopy senescence during grain filling could increase the yield potential of crops that are not sink limited in these crop species, for example by increasing source to match increases in grain sink size so that crops do not become source-limited. Since new maize hybrids in the USA produce greater biomass because they are photosynthetically active for a longer period of time during mid- to late grain filling, there is some indication that maize may fit into this group. Slow leaf senescence has also been linked in part to yield increases in super 'hybrid' rice.

Senescence-related variables have rarely been studied in experiments using collections of historical cultivars of wheat and barley. In wheat, there were no differences in the length of the leaf during grain filling across cultivars introduced in Argentina at various times. Although there were changes in senescence patterns amongst wheat cultivars introduced in the UK at various times, these weren't related to output. The stay-green trait, or delayed senescence linked to prolonged photosynthesis, has primarily been investigated as a trait for enhancing abiotic stress tolerance as opposed to yield potential up to this point. Research has provided some insightful information about the physiological and genetic mechanisms behind stay-green. Stay-green is significant as a marker of wheat's ability to withstand heat and sorghum's ability to withstand drought.

Stay-green in sorghum is associated with continued N uptake following anthesis, indicating some complexity in the trait that might be the result of a fusion of root and shoot features. Durum wheat was found to contain four "stay-green" mutations that, in glasshouse tests, enhanced grain weight per plant and extended photosynthesis during grain filling. A transcription factor speeds up senescence and boosts the movement of nutrients from leaves to growing grains in the wild emmer wheat ancestor. Even though reintroducing the functioning allele will not increase canopy survival, the gene offers a starting point for identifying the genes that control senescence.

In many grain crops, assimilate reserves from vegetative tissues are remobilized during grain filling to complement the assimilate from current photosynthesis. As a result, by the time cereals began to flower, reserves of non-structural carbohydrates had amassed in their vegetative organs (stems and leaf sheaths). Wheat and barley accumulate the most right after flowering, rice around heading, and maize right around silking. In sunflower, Nonstructural Carbohydrates (NSC) accumulation peaks in stems before or soon after flowering and typically continues well into grain filling. The percentage of NSC in the stem at the time of anthesis varies genetically between 5% and 43% in wheat, 20% to 35% in barley, and 15% to 20% in maize.

Different genotypes may have varying capacities for storing carbon reserves, resulting in variances in carbon availability. Under extreme dryness, Nonstructural Carbohydrates (NSC) disappearing from the stems of wheat, barley, rice, and sunflower are significant factors in grain growth. Choosing cultivars with higher stem NSC levels at anthesis had less advantage because so much of the NSC was consumed for maintenance. This was confirmed by a study using alternative stem NSC choices at anthesis, which found no link between reduced stem NSC per plant and decreased drought tolerance during grain filling. Sucrose, which in maize continues to build up after stem elongation, can, however, be remobilized to aid grain development during grain filling under drought-stricken conditions.

The value of stem NSC at anthesis for grain yield varies depending on the crops, species, and environment, however in contemporary cultivars of wheat, barley, and rice, NSC can be a significant contributor to yield. In winter wheat, cultivars introduced at various times showed favorable relationships between stem NSC content and grain yield; stem NSC was estimated to account for 28% of yield. According to estimates, stem NSC accounts for between 20 and 30 percent of the output in both rice and winter barley grown in the UK.

About 15%-20% of the total carbon absorbed by sunflower grain in irrigated crops was provided by pre-anthesis NSC. Finding the optimum NSC concentration for each of wheat, barley, and rice is necessary, though, as NSC concentrations above a certain point may indicate reduced allocation to the ear or to structural vegetative organs, which could be linked to an increased risk of lodging or premature leaf senescence.