MEASURING RADIATION USE EFFICIENCY OF COTTON GROWN IN THE ARID SOUTHWEST

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Abstract

Radiation use efficiency (RUE) is defined as the biomass produced given the total solar radiation intercepted by the crop canopy. While the concept of RUE might seem very simple, it is in fact quite difficult to measure. RUE is the outcome of several different traits including photosynthesis, carbon partitioning, and canopy or leaf architecture. Previous studies have found that plants in-general, are very inefficient at utilizing solar radiation to produce biomass, only 3-4% of the total incoming radiation for C3 plants and only 4-6% for C4 plants. In upland cotton, the estimates are even lower ranging from 1-2.5% efficiency. Studies in soybean and maize have shown that increasing RUE, either by increasing the intercepted radiation or leaf photosynthesis, can also increase crop yield. Given the potential for yield improvement, RUE is something breeders should focus on in their programs; however, measuring RUE is very labor intensive and requires destructive plant sampling which may not be possible in early generation breeding material. In order to make measuring RUE feasible for breeders, a moderate to high-throughput phenotyping method is needed that requires little to no destructive plant sampling. At the US Arid Land Agricultural Research Center in Maricopa Arizona, a row-bot and proximal sensing cart were developed to measure light interception, and inputs for modeling biomass. The cart and row-bot were deployed in a small upland cotton breeding trial after reproductive growth began. Manual measurements were also taken to determine if the carts and sensors could accurately capture light interception and model biomass. Manual measurements were also taken to determine the effect of leaf size on light interception and the photochemical efficiency of each line. Initial analysis indicates the high-throughput method for capturing light interception in upland cotton is effective, but that modeled biomass was inaccurate. Analysis also shows that leaf area was a major contributor to light interception and correlated with harvest weights ($r^2 = 0.7525$). Measurements of dark-adapted chlorophyll fluorescence using a fluorpen showed that cotton lines tested have low minimum fluorescence (F_0) but increased maximum fluorescence (F_M). This study indicates that two areas where breeders can improve radiation use efficiency in cotton are increased leaf area to improve light interception, and dark green leaves to improve F_0.