

Growth Analysis of Biomass Production in Sole-Crop and Double-Crop Corn Systems

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ABSTRACT

Increased biomass productivity could be achieved through double-cropping if extended growth duration could be realized with minimal reductions in growth efficiency relative to sole-cropping. To test this hypothesis, functional growth analysis was used to assess the relative importance of photosynthetic duration and efficiency in determining biomass production by sole-crop corn (*Zea mays* L.; SC) and double-crop triticale (*xTriticosecale* Wittmack)–double-crop corn (DT–DC). Aboveground dry matter and leaf area were measured weekly, and net dry matter production was assessed for each crop at harvest. Over 2 yr, average harvested dry matter was 25% greater for DT–DC (22.7 Mg ha⁻¹) than for SC (18.2 Mg ha⁻¹), despite greater maximum leaf area index and greater maximum crop growth rate for SC relative to DT–DC. Leaf area duration was increased by 23% for DT–DC compared with SC, while maximum net assimilation rate and seasonal net assimilation rate did not differ between cropping systems. Across systems, variation in yield was positively related to maximum crop growth rate, maximum leaf area index, and leaf area duration but was not associated with maximum or seasonal net-assimilation rate. Therefore, leaf duration was more important than leaf efficiency in determining productivity in both cropping systems, and greater biomass yield for DT–DC was the outcome of photosynthesis occurring over an extended duration. These results suggest that potential exists to increase biomass productivity by expanding the seasonal interval of photosynthesis, and that in the case of double-cropping, expansion of leaf duration is not necessarily associated with reductions in leaf efficiency.

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Abbreviations: ANCOVA, analysis of covariance; CGR, crop growth rate; DC, double-crop corn; DM, dry matter; DOY, day of year; DT, double-crop triticale; HDM, harvested dry matter; LAD, leaf area duration; LAI, leaf area index; NAR, net assimilation rate; SC, sole-crop corn; SNAR, seasonal net assimilation rate.

RECENT YEARS HAVE WITNESSED an unprecedented surge in global demand for agricultural products. Rapid rates of population growth, increasing caloric intake and animal protein consumption in emerging economies, and the expansion of bio-fuel production have all contributed to demand escalation and are expected to continue to do so over the coming decades (Trostle, 2008; Abbot et al., 2008). Furthermore, it is anticipated that in the near future, new demand will emerge for lignocellulosic biomass as a feedstock for the manufacture of ethanol and other advanced biofuels and bioproducts (Brown, 2003; Greene et al., 2004; Perlack et al., 2005). Therefore, meeting society's future food, fuel, and material requirements will require productivity gains not only for cereal-based cropping systems but also for crops and cropping systems designated for the production of cellulosic biomass (Sims et al., 2006; Cassman and Liska, 2007; Fales et al., 2007).

One potential strategy for increasing the biomass productivity of agricultural land is through the use of double-cropping systems (Lewis and Phillips, 1976) that include biomass cover crops (Karpenstein-Machan, 2001). In such a system, two crops are harvested from

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