Identifying common crop traits to address the variability in tiller production between sorghum and rice canopies

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Abstract

Developing a common mechanistic model to predict tiller dynamics in sorghum and rice canopies growing in favorable conditions can greatly contribute to the identification of common genetic regions involved in tiller production of both species. Crop growth processes of a high-tillering sorghum hybrid, grown in different plant densities in Australia, and a conventional rice inbred, grown during several crop seasons and under several crop management techniques in the Philippines, were quantified. Total tiller production per plant was up to 6 for sorghum growing at 2 plants m^{-2}, and up to 30 for rice growing at 25 plants m^{-2}. Only primary tillers were observed on sorghum, whereas secondary and tertiary tillers developed on the rice plant. Rate of tiller emergence for sorghum was linearly related to leaf number on the main tiller, with the first tiller emerging at leaf number 6 (when the incomplete leaf was counted) and tiller 5 emerging at leaf number 10. Even if the rate of tiller emergence in rice was exponentially related to leaf number, that of the primary tiller was also linearly related to leaf number, with the same characteristics as that in sorghum. This was also probably the case for emergence of secondary tillers related to leaf number of their mother primary tiller. Dynamics in leaf emergence on primary tillers was identical to that of the main tiller in sorghum and rice. Cessation in tiller emergence in sorghum was correlated to a unique value of leaf area index, 0.6, when plant densities from 2 to 16 plants m^{-2} were considered. Cessation in tiller emergence in rice occurred, however, with leaf area index between 1.0 and 3.5, with crop stage between 15 and 2 days before panicle initiation or between 9 days and 1 day before start in internode elongation, when considering a large number of field experiments. Delayed cessation in secondary and tertiary tiller emergence compared to that of primary tiller emergence may suggest considering tiller order to predict cessation in tiller emergence. Tiller senescence for both sorghum and rice systematically concerned the youngest tillers of the plant, whatever their order was. The impact of tiller senescence on grain yield appeared, however, different between sorghum and rice. Grain yield of sorghum, when grown at 16 plants m^{-2}, increased from 9.2 to 11.5 t ha^{-1}, and tiller mortality rate decreased from 0.7 to 0, if all individual tillers were systematically removed from the plant as soon as they appeared. However, decrease in rice tiller mortality rate, from 0.33 to 0.24 by increasing water depth at mid-tillering, or from 0.53 to 0.39 by transplanting younger seedlings, did not affect grain yield. Even though tiller production was highly different in rice and sorghum canopies, most of the features describing tiller dynamics were relatively consistent for both species according to the genotypes and growing conditions considered here. It may be possible to develop a common model for both species as long as control of cessation in tiller emergence and tiller senescence impact on grain yield are clearly assessed.
Keywords: grain sorghum, rice, tiller emergence, leaf emergence, tiller senescence, modeling