Development of 3-D topometric imaging and 2-D photogrammetry methods for high-throughput phenotyping of perennial ryegrass spikes

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Abstract

Advances in technology have increased adoption of high-throughput phenotyping (HTP) methodologies, potentially replacing laborious and time-consuming measurements and data recording. One promising HTP tool for fine-featured and small-sized characteristics are 3-dimensional (3-D) scanning and imaging systems, but the utility of present 2-D technology has not been fully explored for this purpose. The objective of this work was to develop 2-D photogrammetric and 3-D topometric imaging methods for HTP of spike characteristics in perennial ryegrass (Lolium perenne L.) with special attention to traits that might be associated with seed retention. These HTP imaging systems were compared with direct data capture by hand in spikes of 21 diverse global accessions of perennial ryegrass. The Fiji (ImageJ) open source imaging software was used for photogrammetric analysis of spike structure including spike length, spikelet number, internode length and 2-D curvature of the spike. The optical sensor Artec Space Spider 3-D scanner was used to generate dense 3-D point clouds to measure spike length, spikelet number, internode length, spikelet length, spikelet angle, and 3-D curvature of the spike. Both methods were found to accurately characterize the subject, the 3-D method was slower than 2-D but was more (P [?] 0.01) precise than 2-D image analysis with a linear measurement deviation of only 0.17%. Fiji was effectively used for post-processing image analysis and the Space Spider can be used directly in the field to support HTP data collection. This non-destructive field measurement system facilitates HTP in perennial ryegrass spikes and likely in other applications.

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